

Strengthening Systems Engineering

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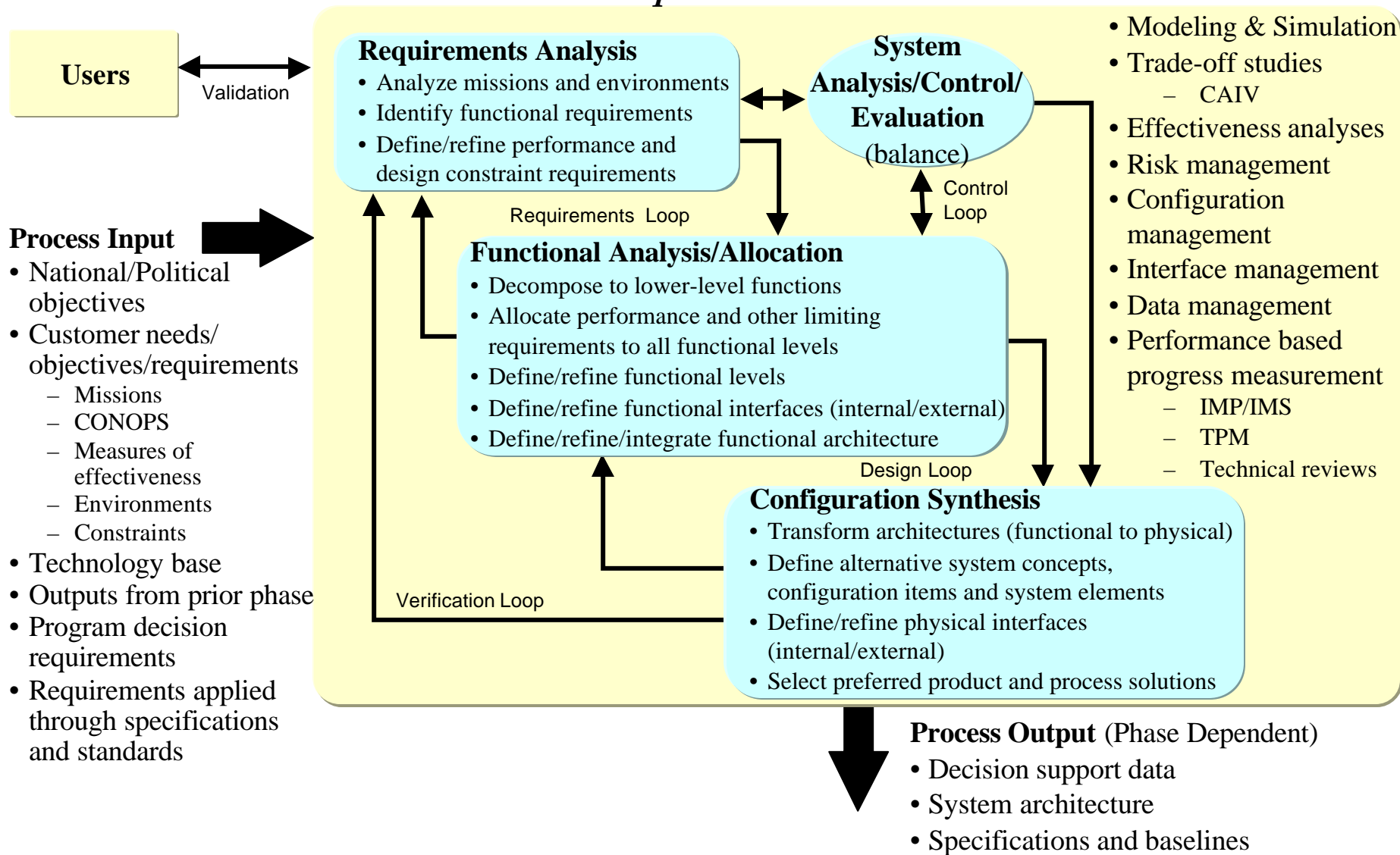
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Topics

- **Define Systems Engineering**
 - Major Elements
- **Current Challenges**
- **Changing Environments/Future Trends**
- **Summary of Suggested Actions**

The Systems Engineering Process

A Logical, Consistent Sequence of Activities Controlled and Managed to Meet Customer Requirements



Major Elements of Systems Engineering

- **Requirements Development**
 - Ops Analysis in **Front End of Business planning**
- **Up Front Program Planning**
 - Conduct **requirements definition/analysis**
 - Develop **integrated master plan**
 - Establish **system baselines**
 - Define Systems Engineering Integration Team (SEIT) **role in organization**
 - Develop and manage **affordability strategy**
- **Performance to Plan**
 - Manage **trade studies/decision analysis process**
 - Manage **risk management process**
 - Perform **functional analysis/allocation**
 - **Allocate and roll-up of requirements; perform requirements management**

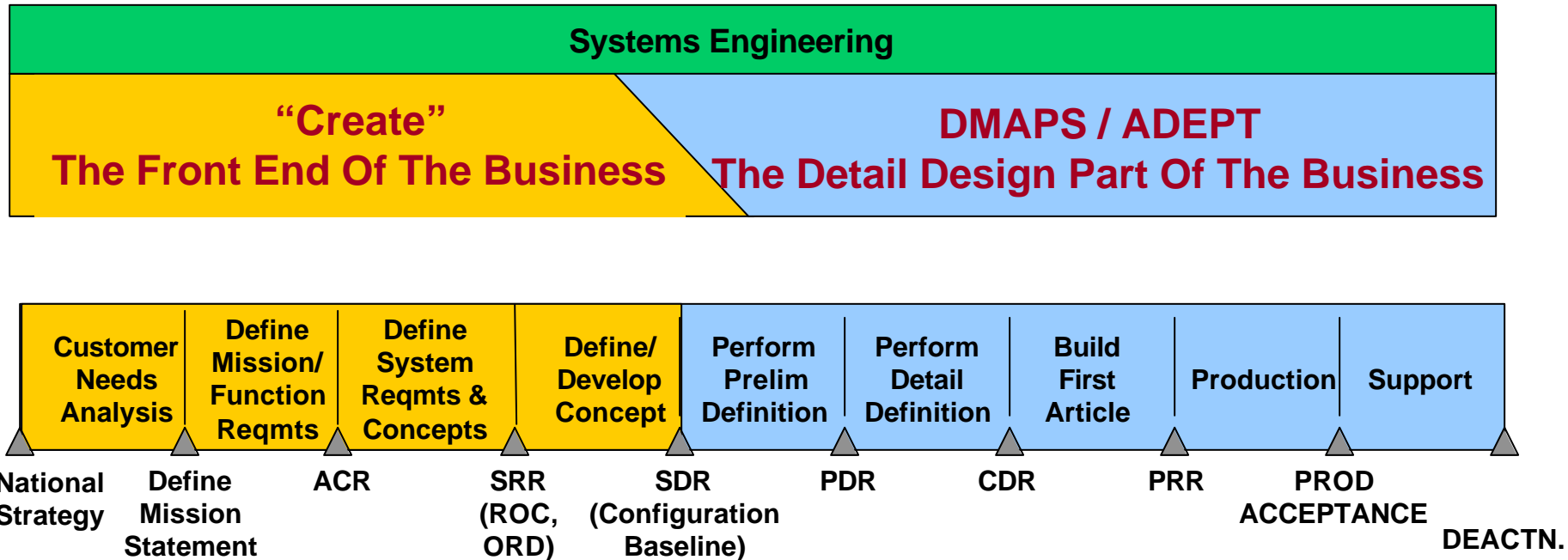
Major Elements of Systems Engineering

- Perform **Configuration Management (CM)**
- Perform **Data Management (DM)**

Integration

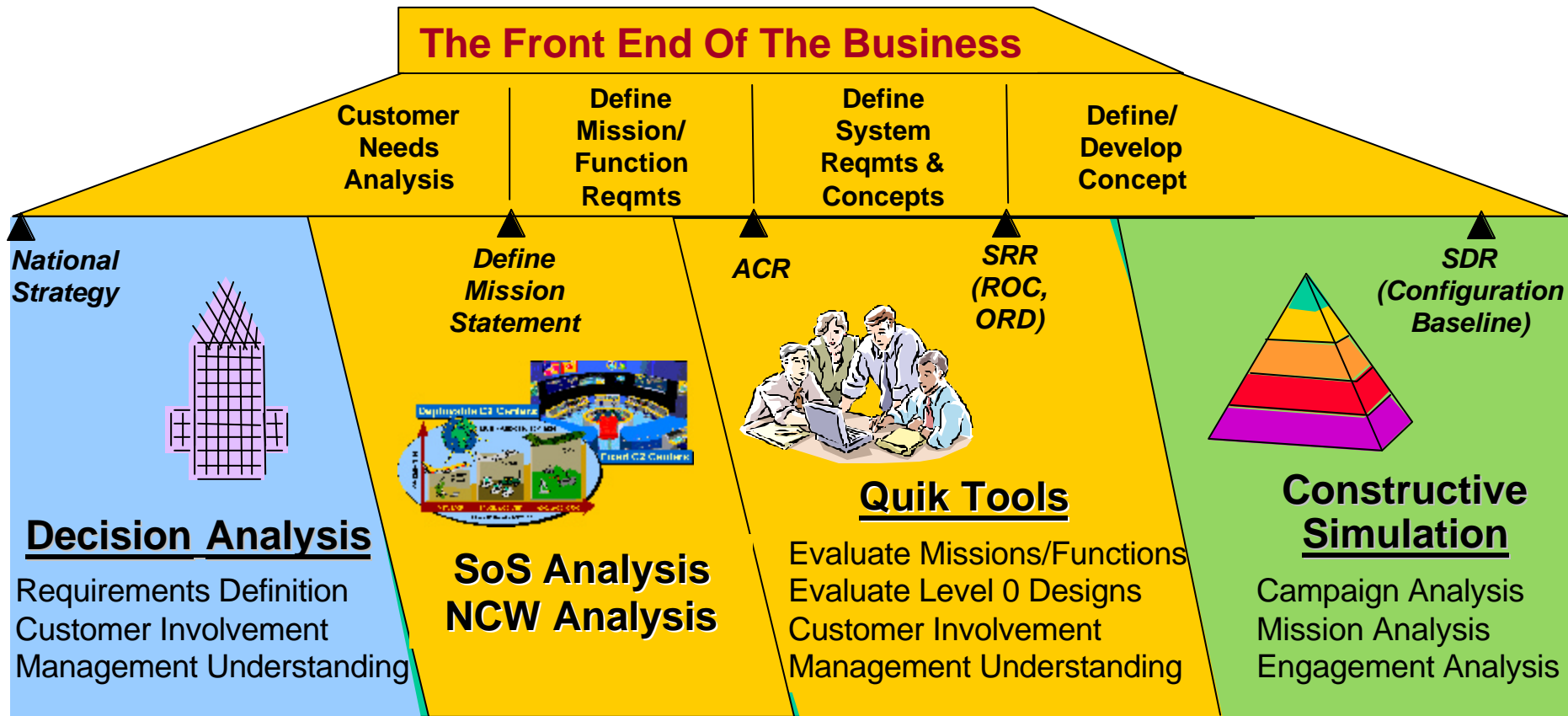
- **Interface management** (requirements, processes, including ICD's)
- **Maintain and track integrated master plan**
- **Manage Integrated Digital Environment**
- **Integrate specialty engineering**
 - Safety; Human Factors; Ship Suitability
 - Reliability, Maintainability and Testability
 - Interoperability; Supportability
 - Vulnerability; Life Cycle Cost
 - Effectiveness; Survivability
- **Measure**
 - Manage **Technical Performance Measurements (TPMs)**
 - Manage **verification and validation process** to system requirements
 - Facilitate **independent reviews/assessments**

What is The Front End of the Business?



"Creating" the FEOB is the Critical First Part of Systems Engineering

Match Tools to Front End of the Business Phase



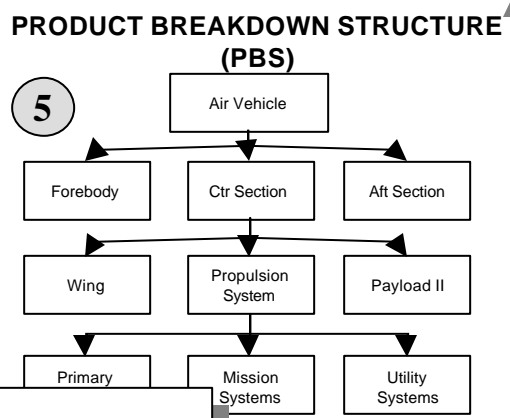
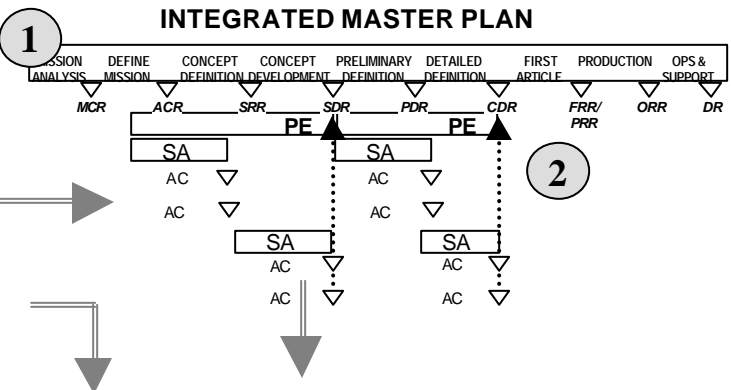
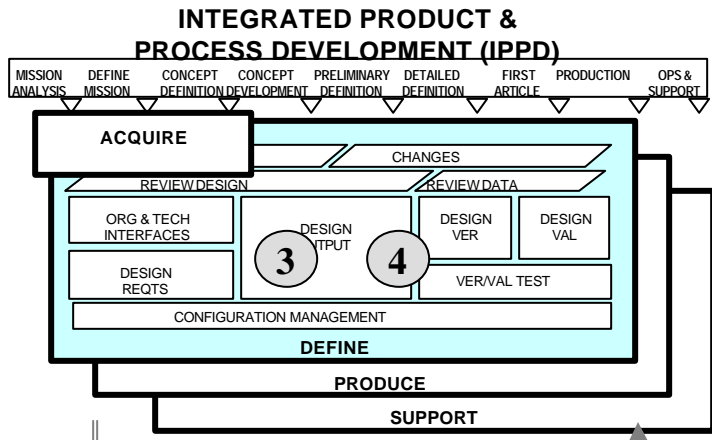
Need Tools & Processes for Each Phase of FEOB

Strengthening Systems Engineering

Process Architecture Facilitates SE Process

PROGRAM/PROJECT PLANNING

- Functional Requirements
- Contract Review
- Customer Inputs
- Company Databases
- Lessons Learned
- Technology Development



INTEGRATED MASTER SCHEDULE

IMS DESCRIPTION	WBS	SOO	W1	W2	W3	W4	W5
MCR	1	1.0					
Establish System Requirements	1	1.1					
Select System Concept	1	1.2					
ACR	2	2.0					
Develop System Configuration	1	2.1					
Establish Segment_X Requirements	X.1	2.2					
Select Segment_X Concept	X.1	2.3					
SRR	3	3.0					
Integrate System Configuration	1	3.1					
Verify System Configuration	1	3.2					
Develop Segment_X Configuration	X.1	3.3					
Establish Subsystem_X Requirements	X.Y.1	3.4					
Select Subsystem_X Concept	X.Y.1	3.5					
SDR	4	4.0					

- 1 Select Program Events
- 2 Identify Significant Accomplishments
- 3 Identify Accomplishment Criteria
- 4 Identify Tasks
- 5 Allocate to PBS/Organizational Structure
- 6 Establish Task Interrelationships

SEPM
 Program Milestones
 Significant Accomplishments
 Accomplishment Criteria

PLCP
 Phase Exit Criteria
 Task Identification
 Task Interrelationships

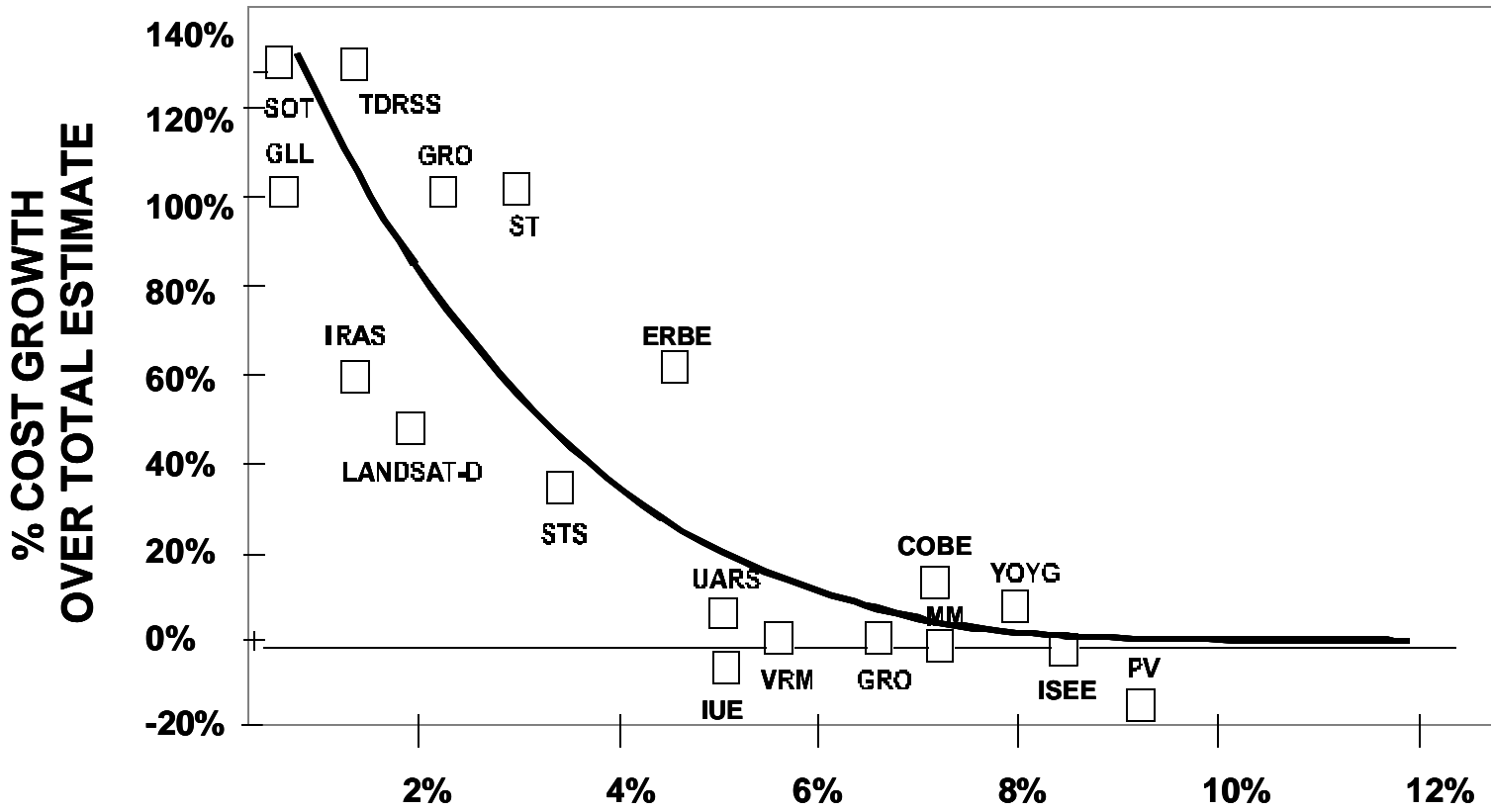
+ = **Tailored Product Definition Template**

Current Industry Challenges

- Synchronizing requirements, acquisition, and budgets so **spiral development** really works (Chart 12)
- **Common understanding of Systems Engineering (SE)** across industry and with government customers
- Dealing with **multiple capability assessment processes** while minimizing the disruptive impact on programs (Chart 15, 16)
- **Quantifying the “Value of Systems Engineering”** (Chart 10)

Quantifying the “Value of Systems Engineering” Impact of “Front-End” Investment

Pre-Cost Commitment Investment vs. Total Cost Growth



% Investment in
System Definition and Analysis

Source Werner Gruhl
NASA Comptroller's Office

Changing Environments/Future Trends

- **Acquisition Reform/Excellence**
 - Spiral Development (Chart 12)
 - Simulation Based Acquisition
 - Performance Specifications
- **Network Centric Operations**
 - System of Systems Engineering (SoSE) (Chart 13)
- **Capability Maturity Model-Integration (CMMI)**
(Chart 14)
- **Integrated Collaborative/Digital Environment**
(Chart 17)

**Essential to Proactively Respond to Changing
Environments/Future Trends**



Spiral Development Stresses Upfront Processes (Notional UCAV as an Illustration)

FY99-00 FY01 FY02 FY03 FY04 FY05 FY06 FY07 FY08 FY09 FY10 FY11 FY12 FY13

Concept Demo

Development

Traditional

Pre-Production

Production

Focused S & T with Funding Flexibility for Rapid Insertion of Technology

System Collaborative Demo

Development

COA

Feedback Loop A

Feedback Loop B

Spiral 1 Production

COA

Requirements
Refinement

Fieldable Prototype Demo

COA

Spiral 2

COA

Spiral 3

COA

Collaborative
Spirals

Continuous User Assessment & Collaboration, Sustainment & Conops Refinement

COA = Collaborative Ops Assessment



Requirements/S&T

What is a “System of Systems”?

SoSE

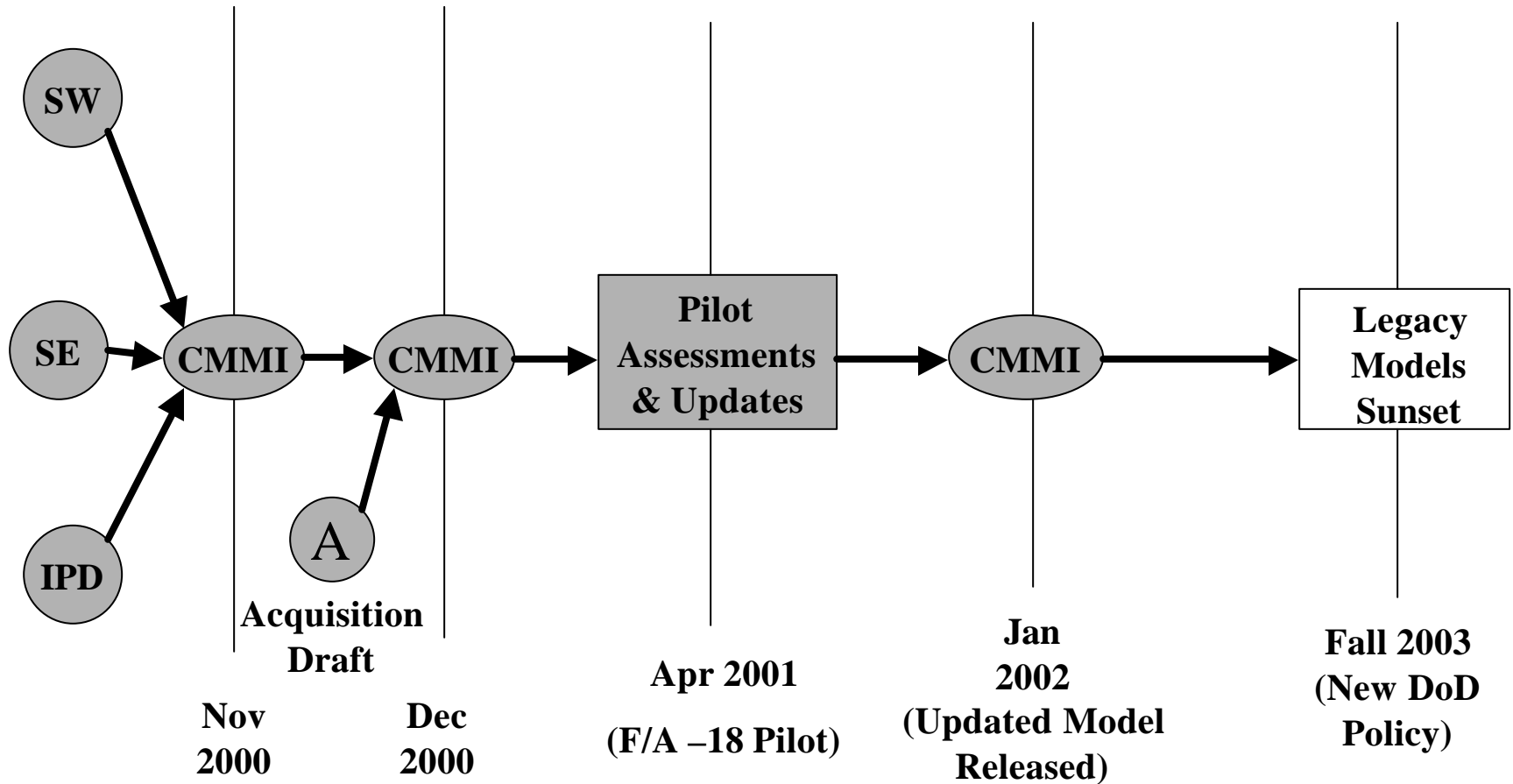
- *Definition:*

A System-of-Systems (SoS) created for joint operations is a “super-system” comprised of elements that are themselves complex, independent systems which interact to achieve a common goal.

- *Common Characteristics:*

- Operational Independence of elements
- Elements possess the required Interoperability
- Development & Existence is Evolutionary
- Emergent behaviors and capabilities
- Geographically distributed

Evolution of CMMI



Need to Mature Capability Maturity Model-Integration (CMMI) and it's use

Multiple Process Improvement Initiatives

- **Capability Maturity Model-Integration (CMMI)**
 - Framework for improving organizational processes
 - Required for DoD ACAT I programs beginning in CY2003
- **International Standards Organization (ISO)**
 - Process documentation standard
 - Quality measurement system for ISO registration
- **Lean Enterprise Self-Assessment Tool (LESAT)**
 - Business unit focus on processes leading to the efficient use of assets, short cycle times, high quality, and low transaction costs
 - Comprehensive process guide at an extremely high level
- **Lean Engineering**
 - Focus is on specific tools and methods at a lower level than other initiatives
 - Provides detailed “how to” strategies for improving performance
- **Program Management Best Practices (PMBP)**
 - A set of practices proven to improve performance to plan
 - Best practice assessments focus on program management processes
- **Malcolm Baldrige**
 - Structured framework to facilitate continuous improvement
 - Quality measurement system based on criteria for performance excellence

Mapping the Initiatives Against Common Process Areas Shows Considerable Synergy

Common Process Areas	CMMI	ISO	LESAT	Lean Engr.	PMBP	Baldrige
Strategic Planning						
Customer and Market Focus						
- Product Integration						
- Requirements Development						
- Requirements Management						
- Technical Solution						
- Validation						
- Verification						
- Customer Communication & Contact Planning						
Process Management						
- Organizational Innovation & Deployment						
- Organizational Process Definition						
- Organizational Process Focus						
- Organizational Process Performance						
- Organizational Training						
Leadership						
- Manage Business						
- Integrated Project Management for IPPD						
- Integrated Teaming						
- Project Monitoring & Control						
- Project Planning						
- Quantitative Project Management						
- Risk Management						
- Supplier Agreement Management						
- Integrated Supplier Management						
Information & Analysis						
- Causal Analysis & Resolution						
- Configuration Management						
- Decision Analysis & Resolution						
- Measurement & Analysis						
- Process & Product Quality Assurance						
- Provide Support						
Human Resources Focus						
- Organizational Environmental Integration						
Business Results						

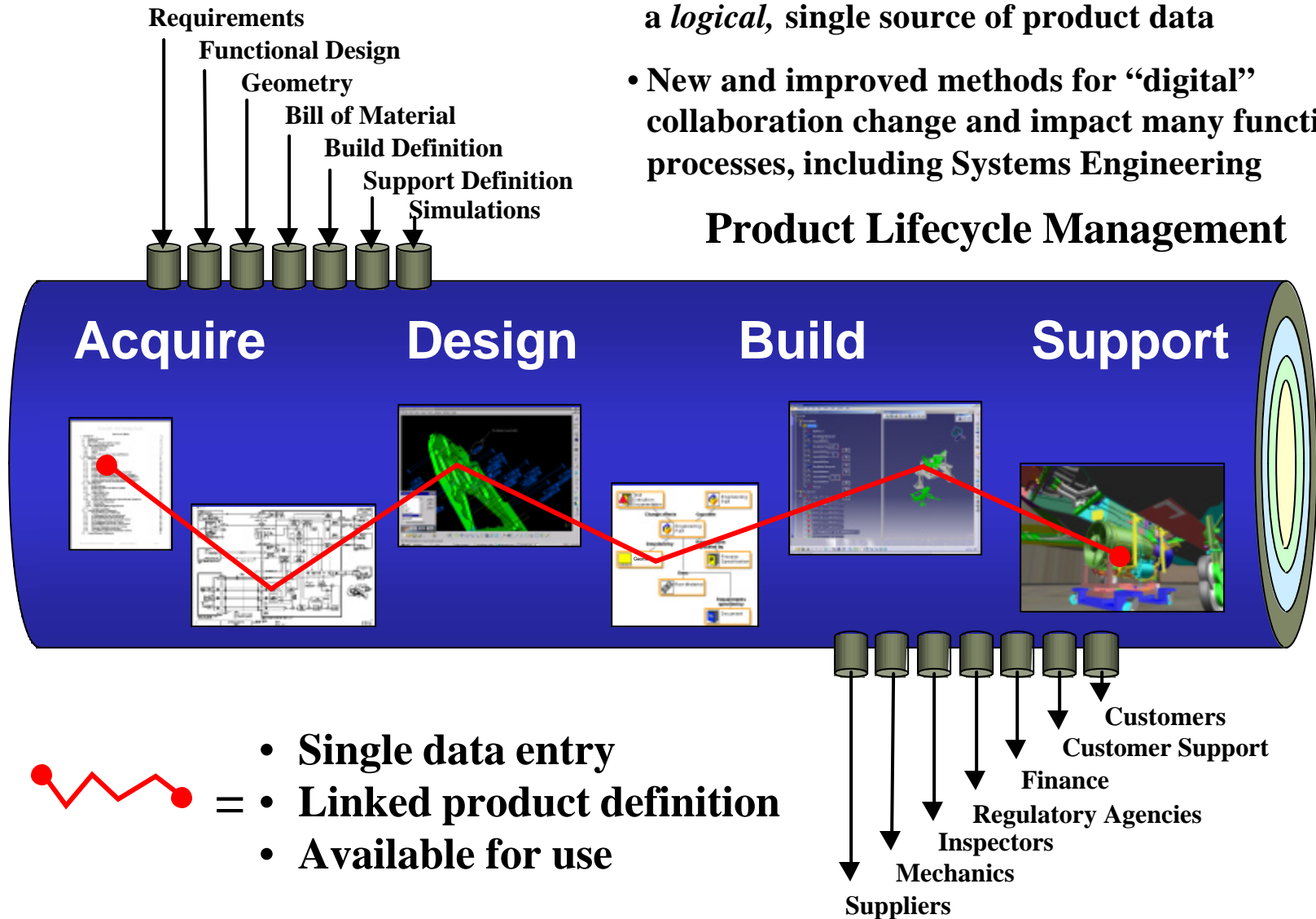
	Mostly Covered
	Some Coverage
	Very Little Coverage
	No Coverage

Focusing on CMMI and Malcolm Baldrige Will Provide >90% of the Benefit

Digital Authoritative Data

- New & future programs are moving rapidly toward a *logical*, single source of product data
- New and improved methods for “digital” collaboration change and impact many functional processes, including Systems Engineering

Product Lifecycle Management



Summary of Suggested Actions

- **Develop SE Process Architecture Over System Life Cycle**
- **Integrate SE in Front End of Business**
- **Embed Key SE Elements in the Program Management Process**
- **Mandate Streamlined Engineering Maturity Assessment Process based on CMMI**
- **Integrate SE with the SoS Process**
- **Develop “Collaborative/Digital Environment”**
- **Develop and Pursue Joint Strategy for Strengthening SE with DoD**